A Cephalometric evaluation of Nasopharyngeal Airway Dimensions and Craniofacial Morphology in Pre and Post Adenoidectomy Cases

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CERTIFICATE

This is to certify that the dissertation entitled as **"A CEPHALOMETRIC EVALUATION OF NASOPHARYNGEAL AIRWAY DIMENSIONS AND CRANIOFACIAL MORPHOLOGY IN PRE AND POST ADENOIDECTOMY CASES"** done by **Dr. JAYA PRAKASH TR ,** Post Graduate student, M.D.S, Branch V - Orthodontics, Saveetha Dental College and Hospitals, Chennai submitted to The Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment for the M.D.S. degree examination in February 2005, is a bonafide research work done under our guidance and supervision.

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INTRODUCTION

Ever since the time of Angle[4], the effects of upper airway obstruction has long been recognized in the field of craniofacial biology. The resulting relationship of variance in breathing pattern to dentofacial form continues to be debated even after a century of conjecture and intense argument.

The enlargement of the lymphoid tissues, adenoids and tonsils are a common problem seen between the ages of 2 to 12 years, when unattended may lead to an obstruction of the upper- respiratory tract, which in turn affects normal dentofacial development.

Various studies conducted over the years in individuals having obstructions of the upper respiratory tract due to an adeno-tonsillar problem, have reported changes and alterations in craniofacial and functional parameters when clinical and radiological methods were used for their evaluation. Changes and deviations from normal were mainly observed in the following areas: -

1. The mode of respiration,
2. Craniofacial morphology, and
3. The posture of the head

Numerous studies have confirmed these craniofacial alterations present among these individuals when compared to normal controls. Among the parameters evaluated in individuals with an altered respiratory mode, positive correlations were found in total facial height, craniocervical angulation, and position of the hyoid bone, position of the tongue and the type of growth pattern.

According to some authors, these observations concerning the type of breathing, head posture and the development of the craniofacial region of children with lymphoidal obstructions of the upper airway tract, appears to be a neuromuscular adaptation to facilitate the maintenance of free oro-pharyngeal airway capacity. The long-term effects of which results in the clinical entity called the “adenoid -facies”.

Solow and Kreiborg[70] explained the cascade of events leading to the development of the “adenoid-facies.” Obstruction of the airway causes a neuromuscular feedback eliciting a postural change due to stretching of the soft tissues which in turn results in the transmission of differential forces on to the craniofacial region causing a morphological change. Harvold[29] summarized that the adaptive neuromuscular response was associated with the following craniofacial features such as a deficient maxilla, high and narrow maxillary vault, increased lower facial height , open bite; the combinations of which are termed as the “adenoid facies” or “the long face syndrome.”

Tonsillectomy and adenoidectomy is a common surgical procedure undertaken primarily for medical reasons and as a means to relieve the upper airway obstruction. Various studies have evaluated the effects of these surgical procedures by assessing the pre and post surgical morphological characteristics (skeletal, dental and soft-tissue) in these individuals and have reported that the differences between the patients and controls had decreased significantly following adenoidectomy.

Solow and Greve[72], observed that there was a two- degree reduction in the craniocervical angulation and in the position of the head in relation to the true vertical, post-adenoidectomy.

Woodside and Linder-Aronson[43,44,45] found that the position of the head in relation to the true vertical was about 2 degree higher in the adenoid children than in the controls and following surgery this difference had disappeared.

Although these studies evaluated specific craniofacial parameters the observations reported were suggestive of a reversion of the abnormal neuromuscular adaptation to a more normal pattern following surgery, as the changes were observed in the degree of craniocervical angulation, the postural position of the head, hyoid bone and the tongue.

The surgical assessment of the oro-pharyngeal airway cephalometrically was first introduced in orthodontics by Schuloff[66] and has now recently been applied by Naoko Imamura[55] for the evaluation of the same in cleft palate patients.

Reports available in literature evaluating the efficacy of these surgical procedures for the adeno-tonsillar problem are rare. Especially, for evaluations concerning the changes in the oropharyngeal airway dimension following surgery.

Although the analysis has been applied in assessing changes in the oro-pharyngeal dimension both before and after adenoidectomy, correlative studies linking the change in oro-pharyngeal airway dimension following adenoidectomy to post-surgical alterations in the craniofacial morphology are few.

Review of literature shall be discussed under following headings,

- Mode of respiration and craniofacial morphology.
- Head posture and cervical inclination.
- Pharyngeal airway.
- Hyoid bone position and airway obstruction.
- Tongue position and airway obstruction.

<u>Mode of respiration and craniofacial morphology:</u>

Robert M. Rubin (1980)[65] conducted studies on mode of respiration and facial growth, and stated that spatial relationship of mandible to craniomaxillary complex is influenced by function of muscular elevators of mandible. One factor acting on the elevators of the mandible is the rest position of the mandible, which may be influenced by the patient's mode of respiration. Obstruction of the nasal airway is followed by the lowering of the mandible to establish an oral airway.

Peter S Vig (1981)[59] studied the relationship between facial morphology and nasal respiration. Concluded that lip incompetence is not synonymous with mouth breathing. Although long-faced subjects as a group had a higher mean value of nasal resistance, the range of variation was so great as to preclude the diagnosis of nasal obstruction from an assessment of facial morphology.

Micheal R Marcotte (1981)[52] studied on head posture and dentofacial proportions and concluded that those with protrusive mandibles tend to have a low head posture and those with retrusive mandibles have a high head posture.

Sosa, Graber and Muller (1982)[74] studied on postpharyngeal lymphoid tissue in Class I and Class II malocclusions stated that airway space did not appear to vary with the type of malocclusion. Some low-level correlation's were found between the size of the nasopharyngeal area and certain skeletal characteristics. The correlation's depended on both the malocclusion type and the sex of the individual.

Ryan Gallagher, LaBanc and Epker (1982)[62] reviewed the relation between nasorespiratory function and dentofacial morphology. The review fails to support a consistent relationship between obstructed nasorespiratory function and the adenoid facies or long-face syndrome.

Bresolin, Shapiro, Shapiro, Chapko, and Dassel (1983)[16] studied on mouth breathing in allergic children: Its relationship to dentofacial development concluded that, mouth breathers had longer faces with narrower maxillae and retrognathic jaws. This supports previous claims that nasal airway obstruction is associated with aberrant facial growth.

Vargervik, M, (1984)[83] studied on morphologic response to changes in neuromuscular patterns experimentally induced by altered modes of respiration, the neuromuscular changes were triggered by complete nasal airway obstruction and the need for an oral airway. The changes in neuromuscular recruitment patterns resulted in changed function and posture of the mandible, tongue, and upper lip. It was concluded that the marked individual variations in skeletal morphology and dentition resulting from the procedures were due to the variation in nature and degree of neuromuscular and soft-tissue adaptations in response to the altered function.

Solow, Siersbæk-Nielsen, and Greve (1984)[72] studied associations between airway adequacy, head posture, and craniofacial morphology, and found that obstructed nasopharyngeal airways were, on the average, seen in connection with a large craniocervical angle and with small mandibular dimensions, mandibular retrognathism, a large mandibular inclination and retroclination of the upper incisors.

Linder-Aronson, Woodside, and Lundström (1986)[43] studied on mandibular growth direction following adenoidectomy to find the changes in mandibular growth direction (MGD) in a 5-year period after adenoidectomies. Analysis showed that during the 5 years after adenoidectomies, the girls had a more horizontal MGD ($P < 0.02$) than did the female controls. A corresponding but not significant trend was found for the boys. The individual growth directions that were obtained following adenoidectomies were more variable than those found in the controls.

Lowe, Gionhaku, Takeuchi, and Fleetham (1986)[47] used three-dimensional CT reconstructions of tongue and airway in adult subjects with obstructive sleep apnea and found that subjects with more severe obstructive sleep apnea tended to have larger tongue and smaller airway volumes. The more obese subjects showed larger tongue surface areas and smaller airway surface areas.

Lowe, Santamaria, Fleetham and Price (1986)[48] studied relationship between facial morphology and obstructive sleep apnea and concluded that sleep apnea subjects showed a posteriorly positioned maxilla and mandible, a steep occlusal plane, overerupted maxillary and mandibular teeth, proclined incisors, a steep mandibular plane, a large gonial angle, high upper and lower facial heights, and an anterior open bite in association with a long tongue and a posteriorly placed pharyngeal wall.

Tarvonen and Koski (1987)[76] studied on craniofacial skeleton of 7-year-old children with enlarged adenoids using lateral cephalogram. It was found that a diagnostically useful characteristic associated with the past history of enlarged adenoids is a dorsal rotation of the mandibular ramus relative to the palate. This feature may also be common to other obstructions of the nasopharyngeal space.

Timms and Trenouth (1988)[79] had done a quantified comparison of craniofacial form with nasal respiratory function and found statistical significance relationships with nasal airway resistance and other craniofacial dimensions particularly the maxillary-mandibular plane angle, the palate-tongue distance, the palatal width, and the facial index.

W. John S. Kerr et al (1989)[85] studied mandibular form and position related to changed mode of breathing – a five-year longitudinal study on 26 children treated for nasal obstruction by adenoidectomy, who exhibited a changed mode of breathing postoperatively. They were compared with a control group matched according to age and sex. Lateral skull radio-graphs were used to examine mandibular morphology. The study revealed a more anterior direction of symphyseal growth in the adenoidectomy group following surgery as well as some reversal of the initial tendency to a posterior rotation of the mandible.

William H. Bacon, et al (1990)[88] performed cephalometric evaluation of pharyngeal obstructive factors in patients with sleep apneas syndrome. In sleep apnoea syndrome patients, the soft palate was elongated; the sagittal dimensions of upper face and anterior cranial base were reduced and correlated with reduced bony pharynx opening; and the increased lower face height was associated with a retruded position of the chin and tongue, thus contributing to lower pharynx crowding. If anatomical rehabilitation of the pharynx is to be envisaged, the leading factors to consider should be: soft palate length, maxillary position, chin and tongue position, in that order.

Tourne(1991)[80] studied on growth of the pharynx and its physiologic implications. The nasopharynx's ultimate patency, however, depends on the growth and relative size of the soft tissues that line the skeletal boundaries. A decreased patency of the oropharyngeal airway can induce some postural adaptations, which secure a constant sagittal dimension at that level. This muscle recruitment is a possible cause of a deviant vertical craniofacial growth pattern.

Adamidis and Spyropoulous (1992)[2] studied on hyoid bone position and orientation in Class I and Class III malocclusions, the findings reveal that Class III patients, especially the boys, show a more anterior position of the hyoid bone and also a reverse inclination. This might have an implication on the function of the suprahyoid and infrahyoid muscles and thus on the direction of mandibular growth. .

Linder-Aronson, Woodside, Hellsing, and Emerson (1993)[44] found changes in incisor inclination and position in both jaws of children during the first 5 years after adenoidectomy. The main change is a significant increased labial inclination of the incisors for the adenoidectomy groups. The study supports the hypothesis that a changed mode of breathing after adenoidectomy is associated with significant labial positioning of the incisor teeth.

Lowe, Fleetham, Adachi, and Ryan (1995)[46] studied cephalometric and computed tomographic predictors of obstructive sleep apnea severity and found that a high apnea index was seen in association with large tongue and soft palate volumes, a retrognathic mandible, an anteroposterior discrepancy between the maxilla and mandible, an open bite tendency between the incisors, and obesity.

Ceylan and Oktay (1995)[17] had done a study on the pharyngeal size in different skeletal patterns and observed that hy-apw4 (most anterior and superior point on the body of hyoid bone to the anterior pharyngeal wall along line intersecting cv4ia and hy) and oropharynx area measurements, become smaller with the increase in ANB angle , and t-ppw (dorsal tongue surface intersecting occlusal plane to posterior pharyngeal wall intersecting occlusal plane) and hy-apw2 (most anterior and superior point on the body of hyoid to the anterior pharyngeal wall along line intersecting cv2ia and hy). Measurements are effected by the sex.

B.Solow et al (1996)[7] studied airway dimensions and head posture in obstructive sleep apnoea subjects cephalometric study was aimed to describe the antero-posterior diameters of the pharyngeal airway and to examine the relationship between these diameters and the posture of the head and the cervical column. Subjects were recorded in the cephalometer standing with the head in its natural position (mirror position). The largest difference was observed at the level behind the soft palate where the diameter was 50 per cent narrower in the OSA sample than in the reference sample. Extension of the cranio-cervical angle and forward inclination of the cervical column were correlated with an increase in the three most caudal airway diameters in the OSA sample: at the uvula, the root of the tongue, and the epiglottis, but only to increase in the lowest diameter in the reference sample. The findings were considered to reflect a compensatory physiological postural mechanism that serves to maintain airway adequacy in OSA patients in the awake erect posture, most efficiently so at the lowest levels of the oropharyngeal airway.

Nonglak Pracharktam, Suchitra Nelson, Mark G. Han. (1996)[57] had evaluated cephalometric assessment in obstructive sleep apnea. The study developed and assessed the feasibility of a craniofacial index score (CIS) in differentiating patients with OSAS from habitual snorers using anthropometric measurements on lateral head radiographs, thirteen cephalometric and four anthropometric measurements were used in a discriminant model to construct the CIS. The model was able to correctly classify 82.1% of the OSAS group and 86.7% of the snoring group. These findings indicate that a CIS constructed from cephalometric and anthropometric measurements can be used to identify subjects with and without OSAS.

JM Battagel and PR L Estrange (1996)[34] studied cephalometric morphology of patients with obstructive sleep apnoea and founded that the lengths of mandibular body, cranial base and cranial base angulation are reduced in OSA subjects. The area of soft palate was increased although the tongue was not. Intermaxillary space length (the distance between posterior pharyngeal wall and tip of lower incisor) was decreased, thus the area in which the tongue had to function was smaller in OSA group.

Tetsuro Yamada, D (1997)[77] studied on influences of nasal respiratory obstruction on craniofacial growth in young macaca fuscata monkeys, this study was conducted to investigate the influences of artificial nasal respiratory obstruction on craniofacial growth in young macaca fuscata monkeys. Nasopharyngeal respiratory obstruction was associated with downward and backward rotation of the mandible, upward and backward growth of the condyle, divergent gonial angle, anterior open bite, and spaced dental arch in the lower anterior region. These changes were significantly greater in the experimental monkeys with heavy respiratory obstruction.

Alan A. Lowe et al (1997)[3] studied cephalometric and demographic characteristics of obstructive sleep apnea: An evaluation with partial least squares analysis. The results revealed that the predictive powers of obesity and neck size variables for OSA severity were higher than the cephalometric variables used in this study. Compared with other cephalometric characteristics, an extended and forward natural head posture, lower hyoid bone position, increased soft palate and tongue dimensions, and decreased nasopharyngeal and velopharyngeal airway dimensions had relatively higher associations with OSA severity .

M.Murat Ozbek et al (1998)[50] studies on natural head posture, upper airway morphology and obstructive sleep apnoea severity in adults and concluded that craniocervical extension and forward head posture were associated with higher disease severity, a longer and larger tongue, a lower hyoid position in relation to mandibular plane , a smaller nasopharyngeal and a larger hypopharyngeal cross-sectional area and a higher body mass index.

Micheal Trenouth et al (1999)[53] studied relation ship of functioning oropharynx and craniofacial morphology and concluded that oropharyngeal air way was positively correlated with length of mandible (Gon-Me), hyoid position (horizantal distance from c3 –h) and cranial base angle(NSBa).

Joanna M Battagel et al (2000)[36] had done a cephalometric comparison of subjects with snoring and obstructive sleep apnoea and concluded that there is no difference in any skeletal and dental variables examined , but in OSA subjects , the soft palate was larger and thicker , both lingual and oropharyngeal areas were increased and hyoid was further from mandibular plane.

Boon H Seto et al (2001)[14] studied maxillary morphology on obstructive sleep apnea syndrome and suggested that obstructive sleep apnoea patients have narrower , more tapered, and shorter maxillary arches than non snoring non apnoeic controls.

Christopher Robertson (2002)[18] studied cranial base considerations between apnoeics and non apnoeic snorers and found no statistically significant differences were observed between the apnoeic and non apnoeic groups in either their skeletal or cranial base measurements, all the linear cranial base dimensions were reduced in apnoeic group with the exception of (S-SE). After the mandibular advancement, significant changes were observed in natural head position with reduction from extended head position to a more upright NHP.

Joanna M Battagel et al (2002)[35] studied on postural variation in oropharyngeal dimensions in subjects with sleep disordered breathing and concluded that when moving from upright to supine position the antero-posterior dimensions of the oropharyngeal airway decreased with severe narrowing behind soft palate, soft palate showed small but significant increase in area , hyoid dropped and moved anteriorly to accommodate the altered bulk of tongue, maintaining a constant relationship with the lower border of the mandible.

UN Bong Baik (2002)[82] studied relationship between cephalometric characteristics and obstructive sites in obstructive sleep apnea syndrome. The study was to investigate the dentofacial characteristics of patients with OSAS with respect to the obstructive sites. The subjects consisted of 30 Japanese men with OSAS divided into 3 groups of 10 patients each. One group had obstruction at the retropalatal and retroglossal region (Rp 1 Rg group), a second group had obstruction at the retropalatal region (Rp group), and a third group had obstruction due to tonsillar hypertrophy (tonsillar hypertrophy group). Among the many dentofacial characteristics of OSAS patients, the tendencies for retrognathia, micrognathia, and skeletal Class II were strongest in the Rp 1 Rg group and somewhat strong in the Rp group. The presence of a long soft palate was dominant in the Rp group, whereas the tendency for a long face was dominant in the tonsillar hypertrophy group. All of the groups shared the characteristic of having an inferior position of the hyoid bone.

Tu lin Arun, et al (2003)[81] studied on vertical growth changes after adenoidectomy and concluded that when compared with the control group, the adenoidectomy group showed a more vertically directed growth pattern, however, there were no vertical growth pattern differences between the two groups of children who had adenoidectomy before and after four years of age.

Head posture and cervical inclination:

Weber, Preston and Wright (1981)[86] on their study regarding resistance to nasal airflow related to changes in head posture.

The study was to determine whether artificially induced extended head posture decreases the resistance to nasal airflow, and concluded that there is no association found between an extended head posture position and a decreased resistance to nasal airflow.

Showfety, Vig, and Matteson (1983)[69] described a simple method for taking natural-head-position cephalograms, using fluid level devise attached to patients temple, the natural head position can be reliably determined and recorded .

Wenzel, Henriksen, and Melsen (1983)[87] done study on nasal respiratory resistance and head posture with the use of intranasal corticosteroid (budesonide) in children with asthma and perennial rhinitis, and concluded that that budesonide nasal spray is capable of reducing nasal obstruction in allergic children and that a reduced nasal resistance leads to a decrease in craniocervical angulation.

Solow and Siersbaek-Nielsen (1986)[71] studied growth changes in head posture related to craniofacial development. The study was done to determine growth changes in posture and craniofacial morphology and found that on the average, a reduction of the craniocervical angle was seen in connection with increased forward rotation of the mandible and an increased craniocervical angle was found in conjunction with a less-than-average forward rotation of the mandible. The true mandibular rotation was masked by remodeling of the lower mandibular border. Craniovertical angles during the observation period showed no associations with the growth changes in craniofacial morphology.

Eva Hellsing et al (1986)[24] studied changes in postural EMG activity in the neck and masticatory muscles following obstruction of the nasal airways and suggested that change in mode of breathing is able to influence head posture , mandibular posture and postural activity in neck and masticatory muscles.

Cooke and Wei (1988)[19] had done study on the reproducibility of natural head posture, and evaluated the effects of ear posts, an external source of eye reference (a wall mirror), sex and time in relation to the reproducibility of NHP in lateral cephalometric radiographs, and concluded that NHP was found to be highly reproducible with the most reproducible immediate recordings (4 to 10 minutes later) taken with a mirror but without ear posts, however, the radiographs tended to be of poorer quality. After 3 to 6 months, NHP was more reproducible with a mirror and with ear posts. Boys looked up more when changing from the self balance position to the mirror eye reference position. No significant change was noted for the girls and no other significant inter sex differences in NHP reproducibility were found.NHP reproducibility was better when a mirror was used as an external source of eye reference, but no significant differences were detected between NHP recordings taken with and without ear posts. NHP recorded with ear posts and with a mirror became slightly less reproducible over time. The method error following 4 to 10 minutes and following 1 to 2 hours was 1.9°. After 3 to 6 months, the method error was 2.3.

Cooke (1990)[20] studied five-year reproducibility of natural head posture and concluded that NHP reproducibility deteriorated over time but showed signs of stabilizing after 1 to 1½ years. The method error was 1.93° after 1 to 2 hours, 2.34° after 3 to 6 months and 3.04° after 5 years. The individual variability of NHP reproducibility also increased over time. The standard deviation of the SN/vertical angulation was 2.61° after 1 to 2 hours, 3.16° after 3 to 6 months and 4.20° after 5 years.

Beni Solow et al (1993)[8] studied on head posture in obstructive sleep apnoea patients and concluded that craniocervical angle NSL/OPT was found to be extremely large compared to controls, supports the hypothesis that upper airway obstruction may trigger an increase in the cranio-cervical angulation.

Luc P. M. Tourne et al (1996)[49] studied immediate postural responses to total nasal obstruction on twenty-five nasal breathing adults who were radiographically examined before and after their nasal respiratory pattern had been artificially eliminated for a period of 1 hour. All subjects coped in their own individual way with the environmental impact. The most generalized findings were parting of the lips ($p < 0.05$), a drop in mandibular position ($p < 0.001$), and a downward movement of the hyoid bone ($p < 0.05$). Cranial extension did not reach statistical significance ($p = 0.06$). Concluded that if the same postural reactions are maintained over a long-term period, they may be instrumental in influencing the vertical craniofacial growth pattern.

Jan Å. V. Huggare (1997)[32] studied on nasorespiratory function and head posture. The aim of study was to assess whether there was any relationship between nasorespiratory function and variables of head posture in 58 young adults. A natural head position roentgenocephalogram was used to measure the craniovertical angulation (NSL/VER), craniocervical angulation (NSL/OPT), and cervical spine inclination (OPT/HOR). The results showed a trend toward enlarged craniocervical angulation and forward inclination of the cervical spine in subjects with a relatively large nasal cross-sectional area. Though the general opinion on the effects of reduced upper airway size on head posture is opposite, these results are an experimental confirmation of the theoretically expected mechanism that leads to increased head extension in obstructed subjects.

Serder Us Umez, et al (2001)[68] found inclinometer method for recording and transferring natural head position in cephalometrics and concluded that the reproducibility of the method was high, and the system was clinically practical for both recording and transferring natural head position in cephalometrics.

Pharyngeal air way :

H. Billing et al (1988)[27] studied on the development of the pharyngeal space and lymphoid tissue on the posterior nasopharyngeal wall- an assessment with regard to heritability, and concluded that genetic factors have a considerable influence on the size of pharyngeal space, the thickness of the posterior nasopharyngeal wall and the nasopharyngeal airway.

Eva Hellsing (1989)[24] studied on changes in the pharyngeal airway in relation to extension of head and concluded that a change from the natural head posture to 20 degree extension resulted in an increase in cervical lordosis and craniocervical inclination , changed position of hyoid bone and increased cross sectional dimensions of pharyngeal air way.

Behlfelt et al (1989)[9] studied the dentition in children with enlarged tonsils compared to control group and concluded that children with enlarged tonsils have more retroclined lower incisors, more anteriorly positioned upper incisors, small overbite. Large overjet shorter lower dental arches, narrower upper arches and an increased frequency of lateral cross bite, obstruction of oropharynx by enlarged tonsils is responsible for functional and /or morphological disorders causing an open posture of the mouth, a lowered anterior posture of the tongue and a low position of the hyoid bone are thought to be associated with the differences in the dentition between the two groups.

Pushker (2001)[60] had done study on pharyngeal airway space changes after counterclockwise rotation of the maxillomandibular complex to evaluate the effects of double-jaw surgery with counterclockwise rotation of the maxillomandibular complex on the pharyngeal airway space and velopharyngeal anatomy in patients with high occlusal plane facial morphology and concluded that the counterclockwise rotation of the maxillomandibular complex may cause a significantly greater reduction in the PAS than is observed with noncounterclockwise movements when mandibular setback is performed.

Naoko Imamura et al (2002)[55] compared the sizes of adenoidal tissues and upper airways of subjects with and without cleft lip and palate and concluded that the larger adenoidal tissues in the CLP/j group(cleft palate juvenile group), compared with those in the control/j group (control juvenile group), decreased to a similar size with aging. However, the more restricted upper airway in the CLP/j group, compared with that in the control/j group, appeared to persist until adolescence.

Hyoid bone position and airway obstruction :

Lee Graber (1978)[40] studied on hyoid bone changes following orthopedic treatment of mandibular prognathism using chin cup therapy stated that at the end of 3 years of treatment the mandible rotated clock wise and hyoid bone moved slightly posteriorly and more inferiorly , and concluded that stability and patency of the pharyngeal airway is the primary factor in hyoid bone positioning.

Bibby and Preston (1981)[12] found, the hyoid triangle analysis ,according to the author the triangle is formed by joining the cephalometric points retrognathion (the most inferior, posterior point on the mandibular symphysis), hyoidale (the most superior, anterior point on the body of the hyoid bone), and C3 (the most anteroinferior point on the third cervical vertebra). The hyoid triangle relates the hyoid bone to the vertebrae and to the mandible. Since the mandibular symphysis is at a level more comparable to the axis of rotation of the head than is the cranium, the effect of head movement will be minimized and thus the hyoid position can be determined more correctly. It is also noted that there is no sexual dimorphism in the hyoid bone position.

Bibby (1984)[13] studied on the hyoid bone position in mouth breathers and tongue-thrusters and concluded that the hyoid bone has a stable position and is independent of any posture alterations due to tongue-thrusting or mouth breathing.

Antje Tallgren and Beni Solow (1987)[5] studied on hyoid bone position , facial morphology and head posture in adults and concluded that position of hyoid in relation to the cervical column showed less variability than the hyoid relationship to the maxilla and the mandible.

Behlfelt. K et al (1990)[10] studied on head posture, hyoid bone and tongue in children with and without enlarged tonsils and concluded that children with enlarged tonsils had an extended posture of head , lowered posture of hyoid bone and an antero- inferior posture of the tongue, the vertical position of the hyoid also reflects the vertical position of the tongue and antero-posterior position of the tongue was closely related to the oro-pharyngeal depth, the postural pattern in children with enlarged tonsils appears to be associated with need for maintenance of free oro-pharyngeal airway capacity.

Nikolai B Harlabakis (1993)[56] studied on the hyoid bone position in adult individuals with openbite and normal occlusion and concluded that there is no difference in hyoid bone in both male and female open bites in horizontal measurements but vertically only the distance from hyoid bone to the palatal plane was found significantly greater in male openbite group due to position of palatal plane in the development of this dentoskeletal malocclusion.The hyoid axis formed significantly higher angles with basion –nasion plane as well as with the palatal plane in open bite groups,while there is no difference in the angle formed by hyoid axis and mandibular plane.The findings strongly suggest that hyoid bone moves in close conjunction with the pharynx, cervical spine and mandibular plane in patients with entirely different skeletal patterns.

Armando Gale et al (2001)[6] studied on hyoid bone position after surgical mandibular advancement and concluded that with surgical mandibular advancement the hyoid bone follows mainly the advancement of the mandible and moves closer to the body of the mandible , and also stated that changes of hyoid bone and head position are difficult to predict.

<u>Tongue position and airway obstruction</u> :

Adamadis and Spyropoulos (1983)[2] studied the effects of lymphadenoid hypertrophy on position of tongue, the mandible and the hyoid bone and concluded that in mouth breathers tongue was positioned downwards and forwards , the mandible showed significant downward inclination and the hyoid bone appeared to follow the inclination of the mandibular plane.

Eung-Kwon Pae et al (1999)[23] evaluated tongue shape in obstructive sleep apnoea patients using morphometric technique - eigen shape analysis, cephalograms were taken of patients in upright and supine positions. Tongue shape variations in supine position were used to distinguished between apneic and non apnoeic group, the results suggest that eigen shape analysis on cephalograms in the supine position may be useful tool to distinguish OSA subjects from non apneic subjects.

SUMMARY AND CONCLUSION

A cephalometric study was conducted to evaluate the nasopharyngeal airway dimensions , position of tongue and hyoid bone , head posture and maxillomandibular angle in a sample of 15 subjects (8 males and 7 females with mean age of 10.5 years) who were diagnosed by an otolaryngologist as having airway obstruction and mouth breathing due to adenoidal hypertrophy. Adenoidectomy was performed on all the subjects to relieve airway obstruction. Normal individuals (15 subjects, 8 males and 7 females with mean age of 10.5 years) without any signs and symptoms of adenoidal hypertrophy served as controls.

Cephalometric comparative assessment were made between presurgical samples and controls, presurgical samples and post surgical samples taken after one month, post surgical samples after one month to controls after one month, and the following observations were made :

- Presurgical sample subjects when compared to controls showed significant reduction in the airway dimensions, anterior and inferior position of the tongue, inferior position of hyoid bone , an extended head posture and increased maxillomandibular angle.
- Postsurgical sample subjects when compared to presurgical subjects showed significant increase in airway dimensions. A superior and posterior positional change of the tongue was seen and the hyoid bone was associated with superior positional change, however the head posture and maxillomandibular angle did not show any discernable change .
- The post surgical samples showed lesser values in airway dimensions, tongue and hyoid bone position when compared to controls after one month. The values for head posture and maxillomandibular angle were moderately increased and was found to be statistically significant.

CONCLUSION

- The present study confirms the role of nasopharyngeal airway obstruction in causing alterations in craniofacial morphology and is in accordance with studies of Linder-Aronson[41,42,43,44,45] Koski and Lahdemaki[39].
- The neuromuscular adaptations that occurred due to airway obstruction, such as extended head posture and altered craniofacial morphology as seen in presurgical sample subjects confirm the "soft tissue-stretch" hypothesis of Solow & Kreiborg[70]. The post surgical observations showed that these neuromuscular readaptations following relieving of nasopharyngeal airway obstruction by adenoidectomy procedure was found to be a slow process as there was only minimum changes in their values found in one month of post surgical evaluation compared to their presurgical values. Hence further long term studies are warranted to evaluate these changes in craniofacial morphology following adenoidectomy.
- One month post surgical airway dimensions increased markedly compared to their presurgical values but could not bring the values equal to that of controls, and may be attributed to the longer duration taken for complete healing and fibrosis of tissues.
- The study would have been more confirmative if cephalometric values are correlated with additional studies of nasal airway resistance including an assessment of airflow dynamics, pressure gradients and the respiratory flow rate which would have provided a more reliable

quantification of the degree of nasorespiratory function and nasopharyngeal obstruction[37,84].

- As the cephalograms are only 2-dimensional representation of 3-dimensional facial structures, future studies should be directed towards usage of advanced imaging techniques like 3-dimensional MRI which would enable an accurate assessment of the true extent of the enlarged adenoid tissue and also help in evaluating the effectiveness of the surgical out come.

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